

# Feed Intake, Nutrient Digestion, Growth and Reproductive Performances of Boran-Friesian Cross Breed Dairy Heifers Through Different Wheat Straw to Concentrate Feeds

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**Abstract:** This study was conducted to examine the effect of different wheat straw and concentrate proportions on feed intake, nutrient digestibility, growth and reproductive performances of F1 cross breed (Boran X Friesian) dairy heifers. Wheat straw (WS) with 93% dry matter content was chopped (3-5 cm in length) and mixed with concentrate, molasses and water. The amount of water used for the preparation of total mixed ration was three fold of the molasses amount. Twelve dairy heifers ( $90.45 \pm 7.37$  kg LW, mean  $\pm$  S.D) were randomly assigned to one of the three dietary treatments (WS80= 80% WS: 20% concentrate; WS60 = 60% WS: 40% concentrate) and WS40 = (40% WS: 60% concentrate) in a completely randomized block design. The diets were offered *ad-libitum* and allowing 15-20% refusal. The experiment was consisted of 345 days of feeding trial and 7 days for the measurement of digestibility. Different wheat straw and concentrate proportion had no significant effect on organic matter intake of dairy heifers. In contrast, dry matter (DM), crude protein (CP) and acid detergent fiber (ADF) and neutral detergent fiber (NDF) intakes were greater when the heifers were fed WS40 versus the other treatments. The greater ( $P < 0.001$ ) DM, CP, ADF and NDF digestibility, feed conversion efficiency and growth rate were observed in WS40 than the other treatments. The greater ( $P < 0.001$ ) body weight at first service for dairy heifers was perceived in WS80 than the other dietary treatments. Conversely, the smallest age at first service, age at first conception and number of service per conception for dairy heifers was noticed in WS40 than the other dietary treatments. Raising dairy heifers by using 40% wheat straw and 60% concentrate can be recommended for practical application.

**Keywords:** Digestibility, Feed Conversion, Feed Intake, Growth Rate

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## 1. Introduction

Well-grown heifers are the best foundation stock of a dairy herd. But in many farms, heifers become the most neglected group which leads to a poor growth rate and age at first calving greater than 24 months. The main objective of heifer rearing program is to achieve appropriate body weight (220kg in Jersey breed) at the breeding age and attaining 1<sup>st</sup> calving at 24 month of age [8]. The use of TMR for young heifers may result in a better balance of nutrient intake by avoiding individual preferences for forage or concentrates. It was found that heifers fed TMR from a young age were able to distribute their feeding activity more evenly throughout the

day and compete less for feed than heifers fed a top-dressed ration [4]. The objective of this study was to examine the influence of different proportion of wheat straw to concentrate based total mixed ration on feed intake, nutrient digestibility, growth and reproductive performance of crossbred dairy heifers.

## 2. Materials and Methods

### 2.1. Description of the Study Area

The study was carried out at Holeta Agricultural Research Centre, Ethiopia. The center is located at 9°03'28.82" E latitude and 38°30'17.59" E longitude at an elevation of

2,400 m above sea level. The mean annual temperature and rainfall during the study year (2020) were 18°C and 1225 mm, respectively.

### 2.2. Experimental Design

Twelve post weaned F1 Boran-Friesian Cross Breed dairy heifers (90.45 ± 7.37 kg and 95±12 days, mean ±S.D, live body weight and age, respectively) were randomly assigned in a completely randomized block design. Heifers were drenched with broad-spectrum anti-helminthic (Albendazole 2500 mg) prior to the commencement of the feeding trial. The heifers were kept in individual pens. Wheat straw (WS) with 93% of dry matter content was chopped by using on-farm hammer mill. A tractor was used as energy sources of chopping wheat straw with a standard size of 2-5 cm. During the chopping process the amount of benzene consumed by the tractor per kg of chopped wheat straw was 2 liters. After the operation of chopping the wheat straw was mixed with concentrate and molasses. Water was also used for the preparation of total mixed ration. The amount of water used for the preparation of TMR was 3 fold of the molasses amount. The three dietary treatments used for 345 days feeding trial were: - WS80 (80% wheat straw: 20% concentrate); WS60 (60% wheat straw: 40% concentrate) and WS40 (40% wheat straw: 60% concentrate). The TMR diets were offered ad-libitum and allowing 15-20% refusal.

Table 1. Feed ingredients in the total mixed rations (DM basis).

Feeds	WS80	WS60	WS40
Wheat straw	80	60	40
Wheat bran	5	10	15
Cotton seed cake	4	8	12
Noug seed cake	3.2	6.4	9.6
Molasses	7.2	14.4	21.6
Urea	0.4	0.8	1.2
Salt	0.2	0.4	0.6
CP (%)	9.29	11.39	12.08
ME (MJ/KgDM)	6.74	7.48	7.78
Price/kg TMR, ETB	5.23	5.46	5.69

CP= Crude protein, ME =Metabolizable energy, TMR= Total mixed ration,

Table 2. Chemical composition of feed ingredients (%).

Feed	DM	Ash	CP	NDF	ADF	ADL	DOMD	ME MJ/KgDM
Wheat straw	92.69	6.94	3.23	75.64	56.4	10.23	34.56	5.53
Wheat bran	87.19	4.01	16.62	36.54	10.96	3.23	78.29	12.53
Noug seed cake	91.93	8.15	38.23	25.79	16.47	4.09	74.88	11.98
Cotton seed cake	91.81	5.07	29.52	47.94	37.17	6.48	45.04	7.21
Concentrate mix	90.28	5.78	17.99	42.83	14.32	5.05	63.18	10.11
TMR1	76.78	7.82	9.29	64.24	42.25	7.55	42.1	6.74
TMR2	64.67	7.92	11.39	66.79	47.48	6.78	46.78	7.48
TMR3	58.78	8.94	12.08	55.95	43.21	8.94	48.65	7.78

DM= Dry matter, OM= Organic matter, CP= Crude protein, NDF= Neutral detergent fiber, ADF= Acid detergent fiber, DOMD= organic matter digestibility, ME =Metabolizable energy

### 3.2. Feed Intake

The different proportion of wheat straw and concentrates based total mixed rations had no negative impacts on organic matter intake but dry matter, fiber fractions (ADF and NDF) were greater (P<0.05) at WS60 than the other

ETB =Ethiopian birr

### 2.3. Digestibility Trial

At the end of the experiment, faces from each heifer were collected for seven days. Feed and fecal samples were analyzed by the methods of [1, 13]. *In vitro* organic matter digestibility was determined by [12] methods.

### 2.4. Statistical Analysis

The data were subjected to analysis SAS procedure [11]. Tukey means separation test at 5% level of significance was used.

The model was:

$$Y_{ij} = \mu + T_i + B_j + E_{ij}$$

Where,

$Y_{ij}$  is the observation on  $i^{th}$  treatment in  $j^{th}$  block;

$\mu$  is overall mean;

$T_i$  ( $i=1, 2, 3$ ) is the effect of  $i^{th}$  treatment;

$B_j$  ( $j=1, 2, 3$ ) is the effect of  $j^{th}$  block;

$E_{ij}$  = Random error (residuals)

## 3. Results

### 3.1. Chemical Composition of Feed

The chemical composition of the feed is presented in Table 2. Among supplemental feed ingredients and the concentrate mix, the two protein source feeds (Cotton seed cake & Noug seed cake) noted to have the highest CP and the lowest digestible organic matter compared to the energy source feed (wheat bran). Noug seed cake was found to be rich in its ash and permanent lignin contents than the remaining protein and energy supplemental feeds. Greater variations of nutrients were observed the TMR diets. The mean CP and *In vitro* organic matter digestibility contents of concentrate feeds in the present study are comparable with the report of [6].

dietary treatments (Table 3). The average daily dry matter and crude protein intakes for the dairy heifers consuming 80, 60, and 40% wheat straw based rations was 6.91, 7.03 and 7.38 kg, and 640, 860 and 960 gram, respectively. The average dry matter intake and bypass' protein derived from the two protein source feeds (Noug seed cake and

cottonseed cake) were greater ( $P<0.01$ ) when there was a high proportion of concentrates in the ration. This finding is consistent with the proportion of chopped maize stover

silage increased in the diet of dairy heifers which leads to depress the intake of dry matter, fiber fractions (NDF and ADF) and nutrient digestibility [5].

**Table 3.** Feed intakes (kg/d).

Feeds	WS80	WS60	WS40	SEM	Significance
Dry matter	6.91 <sup>b</sup>	7.03 <sup>b</sup>	7.38 <sup>a</sup>	0.14	*
Organic matter	6.34	6.46	6.71	0.08	NS
Crude protein	0.64 <sup>c</sup>	0.86 <sup>b</sup>	0.96 <sup>a</sup>	0.07	**
Neutral detergent fiber	4.42 <sup>b</sup>	4.66 <sup>a</sup>	4.06 <sup>c</sup>	0.06	**
Acid detergent fiber	2.90 <sup>c</sup>	3.40 <sup>a</sup>	3.17 <sup>b</sup>	0.03	*
Bypass protein, g/d#	24.04 <sup>c</sup>	48.08 <sup>b</sup>	72.12 <sup>a</sup>	11.34	***

Mean values without common superscripts are different, \*= $P<0.05$ , \*\*= $P<0.01$ , \*\*\*= $P<0.001$ , NS= Non significance, # Protein derived from Noug seed cake and cottonseed cake, SEM= Standard error of the mean

### 3.3. Apparent Digestibility

Digestibility coefficients were reduced as wheat straw replaced with concentrate feed (Table 4). The greater ( $P<0.001$ ) apparent digestibility coefficients of dry matter, organic matter, crude protein and fiber fractions (ADF and NDF) were observed in WS40 than the other treatments. The average dry matter digestibility of the dairy heifers consuming 80, 60, and 40% wheat straw rations was 55.21, 64.32 and 69.97%, respectively. The coefficients of apparent digestibility for dry matter, organic matter and crude protein, acid detergent fiber and neutral detergent fiber values, increased as the proportion of concentrate in the ration

increased [10]. In the present study, dairy heifers fed the WS40 diet, which was the highest coefficients of apparent digestibility for dry matter, organic matter and crude protein, acid detergent fiber and neutral detergent fiber values compared with dairy heifers fed the other dietary treatments which is consistency with the finding of [5, 8] who found that the higher coefficients of apparent digestibility for dry matter, organic matter and crude protein, acid detergent fiber and neutral detergent fiber values, as the proportion of concentrate in the maize stover silage based total mixed ration was increased. In contrast with this finding, the digestibility coefficient for crude fiber decreased as the proportion of concentrate in the ration became greater [10].

**Table 4.** Dry matter and nutrient digestibility coefficients of the dietary treatments.

Apparent digestibility (%)	WS80	WS60	WS40	SEM	Significance
Dry matter	55.21 <sup>c</sup>	64.32 <sup>b</sup>	69.97 <sup>a</sup>	0.55	***
Organic matter	50.60 <sup>c</sup>	59.92 <sup>b</sup>	66.52 <sup>a</sup>	0.72	***
Crude protein	56.92 <sup>c</sup>	66.04 <sup>b</sup>	71.05 <sup>a</sup>	1.00	***
Neutral detergent fiber	55.05 <sup>c</sup>	62.15 <sup>b</sup>	70.72 <sup>a</sup>	0.40	***
Acid detergent fiber	40.12 <sup>c</sup>	51.05 <sup>b</sup>	58.42 <sup>a</sup>	0.25	**

Mean values without common superscripts are different at \*\*= $P<0.01$ , \*\*\*= $P<0.001$

### 3.4. Growth and Feed Conversion

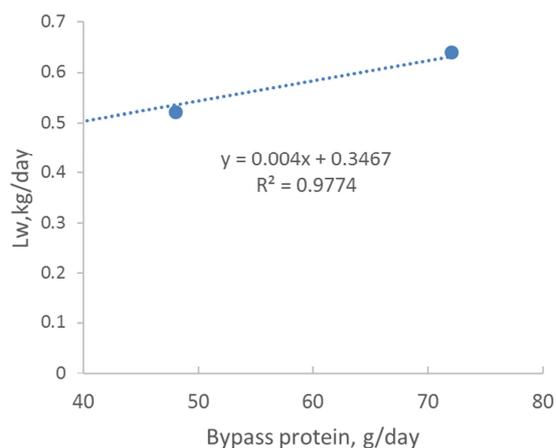
Daily body weight gain, protein and feed conversion of the dairy heifers were depressed with linear trends wheat straw replaced protein-rich concentrate in the diet (Table 5). The higher ( $P<0.001$ ) daily body weight gain, feed and protein conversion efficiency of dairy heifers was observed in 40% chopped wheat straw and 60% concentrate based total mixed ration compared to the other dietary treatments. The average daily dry matter and crude protein intake for the dairy heifers consuming 80, 60, and 40% wheat straw rations was 6.91, 7.03 and 7.38 kg, and 640, 860 and 960 gr, respectively. As the proportion of the concentrate feed in the treatment diet increased from 20% to 60% daily growth rate was increased by 170g. Several possible explanations exist for the higher

daily growth rate of dairy heifers which were fed WS40. First, it may be due, in part, to the 22% dry matter and crude protein apparent digestibility increment which are important to daily body weight gain. Second, the mainly to the increment of protein from Noug seed cake and cottonseed meal that are known to have characteristics that favor protein escape from the rumen and hence more Noug seed cake available to the animal. There was a high relationship between the average daily body weight gain and feed conversion efficiency with bypass protein intake ( $r \sim +0.98$  and  $+0.99$ , respectively, figure 1 and figure 2). This finding is consistent with the finding of [5] who found that the daily body weight gain and feed conversion efficiency for dairy heifers is higher as the proportion of concentrate in the maize stover based total mixed ration became greater.

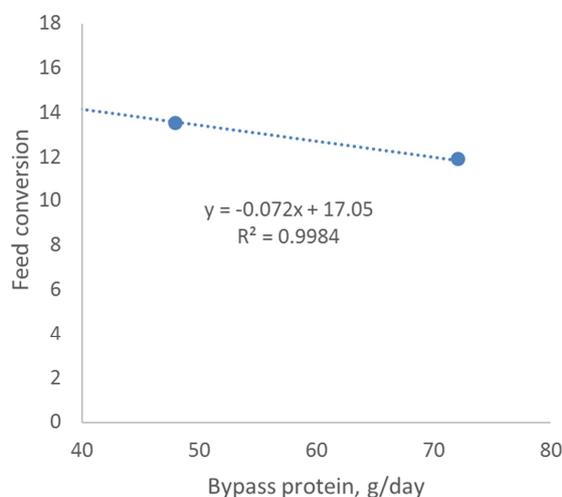
**Table 5.** Growth performance of dairy heifers.

Growth parameters	WS80	WS60	WS40	SEM	Significance
Initial Lwt, kg	91.25	82.71	97.39	4.26	NS
Final Lwt, kg	248.20 <sup>c</sup>	258.66 <sup>b</sup>	296.01 <sup>a</sup>	2.45	*
Daily body weight gain, kg	0.45 <sup>b</sup>	0.52 <sup>ab</sup>	0.62 <sup>a</sup>	0.06	*
DM intake, kg/d	6.91 <sup>b</sup>	7.03 <sup>b</sup>	7.38 <sup>a</sup>	0.14	*
CP intake, kg/d	0.64 <sup>c</sup>	0.86 <sup>b</sup>	0.94 <sup>a</sup>	0.07	*
Feed conversion <sup>#</sup>	15.36 <sup>c</sup>	13.51 <sup>b</sup>	11.90 <sup>a</sup>	1.02	**
Protein conversion efficiency *	0.71 <sup>ab</sup>	0.61 <sup>a</sup>	0.67 <sup>b</sup>	0.03	*

Mean values without common superscripts are different, \* $P < 0.05$ , \*\* $P < 0.01$ , \*\*\* $P < 0.001$ , NS= Non significance, <sup>#</sup>DM intake/ LW gain, \*LW gain /protein intake.



**Figure 1.** Relationship between growth rate and intake of “bypass” protein derived from Noug cake and cottonseed cake.



**Figure 2.** Relationship between feed conversion and intake of “bypass” protein derived from Noug and cottonseed cake.

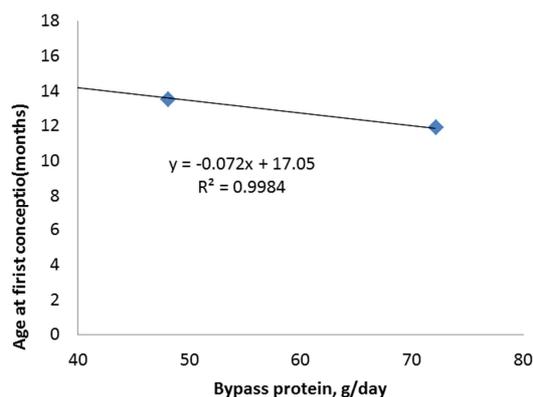
### 3.5. Reproductive Performance

The weight at first service, age at first service, age at first conception and number of service per conception for the dairy heifers is presented in (Table 6). The average weight and age at first of the dairy heifers consuming 80, 60, and 40% wheat straw rations was 254.01, 248.20 and 236.66 kg, and 17.53, 15.91 and 13.23 months, respectively. The greater ( $P < 0.001$ ) body weight at first service for dairy heifers was observed in WS80 than the other dietary treatments. Conversely, the smallest age at first service, age at first conception and number of service per conception for dairy heifers was observed in WS40 than the other dietary treatments. Several possible reasons are exist for the improvement of dairy heifers reproductive performances such as age at first service, age at first conception and number of service per conception First, it may be due, in part, to the higher bypass protein intake, the 22% dry matter and crude protein apparent digestibility increment in the treatment diet. Secondly, the reproductive performances of dairy heifers were improved due to the greater amount of concentrate in ration, feed conversion efficiency and daily growth rate in WS40 treatment diet became greater. There was a linear negative relationship between the age at first conception and bypass protein intake ( $r \sim 0.99$ , respectively, figure 3). In the case of total mixed ration, energy and protein utilization in the rumen was improved and helped to facilitate productive performances of the animals as reported by [9]. The higher weight at first service in TMR feeding in the present study is in agreement with the result of [7] who found the higher weight at first service in a short period for dairy heifers fed that higher concentrate to roughage feeds. Number of insemination per conception in TMR feeding observed in the present study is contrary with the finding of [4] who found no effect of TMR on insemination per conception of dairy cows while the current finding was consistent with the report of [2, 3] who found that the higher concentrate feed in the ration has positive effects on service per conception.

**Table 6.** Performance (Mean  $\pm$  SE) of heifers 'fed total mixed ration and conventional feed.

Parameters	WS80	WS60	WS40	SEM	Significance
Weight at first service (kg)	254.01 <sup>a</sup>	248.20 <sup>ab</sup>	236.66 <sup>b</sup>	5.78	*
Age at first service (months)	17.53 <sup>a</sup>	15.91 <sup>a</sup>	13.23 <sup>c</sup>	1.24	*
Age at first conception (months)	19.70 <sup>a</sup>	18.08 <sup>ab</sup>	15.45 <sup>b</sup>	1.26	*
Number of service per conception	1.75 <sup>a</sup>	1.34 <sup>b</sup>	1.12 <sup>c</sup>	0.21	**

Mean values without common superscripts are different at \*  $P < 0.05$ , \*\* $P < 0.01$ .



**Figure 3.** Relationship between age at first conception and intake of “bypass” protein derived from Noug cake and cottonseed cake.

## 4. Conclusions

It is proposed that the reduction in growth performance was partly due to the 22% decrease in DM and CP digestibility but mainly to the due to reduction in protein from Noug cake and cottonseed cakes that are known to have characterizes that four the escape from the rumen., the smallest age at first service, age at first conception and number of service per conception for dairy heifers was perceived in 40% wheat straw. Raising o dairy heifers by using 40% wheat straw and 60% concentrate can be recommended for practical application.

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